CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-126

April 29, 1982

1. Name of fault.

Green Valley fault

2. Location of fault.

Cordelia and Mt. George 7.5-minute quadrangles, Napa and Solano Counties (figure 1).

3. Reason for evaluation.

Part of 10-year fault evaluation plan (Hart, 1980).

4. List of references.

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5. Review of available data, air photo interpretation, and field checking.

The Green Valley fault zone evaluated in this Fault Evaluation Report (FER) generally is a narrow zone of vertical and near vertical right-lateral strike-slip faulting. Weaver (1949) and Dooley (1973) indicate that Eocene sedimentary rocks may be offset vertically about 500 feet. Estimation of the magnitude of right-lateral strike-slip displacement has not been attempted, although Dooley indicates that two drainages just south of Interstate 80, located 500 to 800 feet east of the principal active fault, are deflected right-laterally about 1200 feet along inferred branch faults (figure 2).

Right-lateral strike-slip displacement along the Green Valley fault may total more than 7 miles since late Pliocene time, based on a rough estimate by this writer of apparent strike-slip separation of Sonoma Volcanics mapped by Sims, et al (1973) across the Green Valley fault. A right-lateral offset of 0.25m along a stone fence built sometime around 1860 and a 0.27m right-lateral offset of a power transmission tower alignment built in 1922 (Frizzell and Brown, 1976) yield fault creep rates of 2mm/yr and 4mm/yr, respectively. Assuming an average slip rate of 3mm/yr, right-lateral strike-slip displacement for the last 3.5 million years would total 6.5 miles. Although a rough correlation between apparent offset of Sonoma Volcanics and estimated slip rates is apparent, several unknown factors limit the reliability of this estimate: 1) the areal extent of the Sonoma Volcanics south of Green Valley is not precisely known; 2) the extent of erosion is unknown in the mountain range to the west of the Green Valley fault; and 3) the rate of strike-slip displacement indicated by offset man-made features is episodic and may not represent a valid rate of displacement through time. However, a significant magnitude of right-lateral offset, possibly on the order of several miles, is indicated.

CORDELIA QUADRANGLE

The Green Valley fault depicted on the 1974 Special Studies Zones (SSZ) Map of the Cordelia quadrangle was compiled based on mapping by Sims, et al (1973), Dooley (1973), Dames and Moore (1972), and Bishop (1972) (figure 2). The decision to zone the Green Valley fault was based on the offset of alluvium mapped by Sims, et al (1973) and Dooley (1973), on trench exposures of faulted alluvium (Dames and Moore, 1972), and a right-laterally offset fenceline indicating fault creep (Dames and Moore, 1972; Bishop, 1972) (figure 2). Mapping of the Green Valley fault completed since the 1974 SSZ map was issued includes Frizzell and Brown (1976), and Helley and Herd (1977) (figure 3a). Traces of the Green Valley fault of Helley and Herd (1977) were compiled from Frizzell and Brown (1976) and are identical.

The Green Valley fault in the Cordelia quadrangle is generally well-defined and there is a fairly good agreement as to the the location of the principal faults, although differences in detail exist (figure 2, 3a). The principal area where disagreement of fault trace locations occurs is in the northern part of the Cordelia quadrangle from section 13, T4N, R3W northward (figures 2, 3a).

Air photo lineaments mapped by Dooley (1973) are located in alluvial deposits east of the main trace of the Green Valley fault (figure 2). These air photo lineaments are based on linear drainages and right-lateral deflections of drainages. Continuous features between these photo lineaments have not been mapped by other workers (Sims, et al, 1973; Frizzell and Brown, 1976). No evidence of continuous features between these lineaments was observed by this writer, based on air photo interpretation. In addition, Burkland and Associates (1976) and Western Geological Consultants (1979) cites Leighton and Associates, (1977) excavated trenches across photo lineaments identified in figure 2 and found no evidence for faulting.

The westernmost fault trace mapped by Dooley (locality 1) is located within massive landslide deposits and has not been verified by other workers (Sims et al, 1973; Frizzell and Brown, 1976) (figure 2). Geomorphic evidence indicating recently active faulting was not observed by this writer, based on air photo interpretation.

The northernmost fault trace of Sims, et al (locality 2) is located about 150-300 feet east of the fault mapped by Frizzell and Brown, (1976) (figures 2, 3a). The fault mapped by Frizzell and Brown is generally well-defined and is characterized by geomorphic evidence of Holocene-active faulting, such as tonal lineaments and scarp in alluvial fan and alluvium, closed depressions, and right-laterally deflected drainages (figure 3a). However, the fault is less well-defined in the northern part of section 35 and cannot be mapped in most of section 26 (figures 3a, 3b).

The southeastern end of the Green Valley fault shown on the SSZ Map of the Cordelia quadrangle is based on Sims, et al (1973) (locality 3, figure 2). The east branch fault trends more to the southeast along a slightly arcuate ridge (figure 2). Frizzell and Brown also map this branch fault (figure 3a), but Dooley (1973) maps this east branch fault as offset by east-west trending faults (figure 3a). No geomorphic evidence of recent faulting along the east branch fault of Sims, et al (1973) and Frizzell and Brown or the east-west trending faults of Dooley (1973) was observed by this writer, based on air photo interpretation (figure 3a). The modified depression mapped by Frizzell and Brown is not clearly ~~related~~ to recent faulting along the west side of the arcuate ridge (figure 3a). Disrupted and deflected drainages and the "swampy area" just off the Cordelia quadrangle (locality 4, figure 3a) are caused by massive landsliding rather than recently active faulting.

The central segment of the Green Valley fault from section 30, T4N, R2W north-northwest to section 13 is generally well-defined and the location of fault traces is in general agreement between Dooley, Sims, et al, Frizzell and Brown, Dames and Moore, and this writer (figures 2, 3a). Trench excavations by Dames and Moore (1972), Burkland and Associates (1973), and Geomechanics (1978) generally confirm the location of faults based on geomorphic features (figure 2, 3a). Trenches by Dames and Moore exposed faulting that offset black adobe soil presumed to be less that 12,000 years old (U.S.G.S., 1973) in the southernmost trench (T-1) (figures 2, 3a). About 400 feet north of this trench, a wire fence is offset "about a foot" in a right-lateral sense (Bishop, 1972). Trench T-2 of Dames and Moore (locality 5, figure 3a) exposed horizontal striations along a fault plane in alluvium (?) (identified by Dames and Moore). Geomechanics (1978) exposed faulted soils in trenches in section 13 that coincide with geomorphic features indicating Holocene faulting (broad linear trough with associated linear depressions, scarp, tonal lineaments, and right-laterally deflected drainages).

Burkland and Associates (1973) exposed evidence for probable Holocene faulting along the west side of the small hill just south of Interstate 80 (locality 6, figure 2). Offset alluvium exposed in the trench coincided with a well-defined west-facing scarplet (figures 2, 3a). Although Frizzell and Brown map this fault, their location is about 100 feet east of where

Dooley (1973), Burkland and Associates (1973), and this writer (figure 3a) map the fault. A moderately east-dipping fault zone that offsets alluvial deposits was exposed by Burkland and Associates (1973) on the east side of this hill (figure 2). This fault exposure coincides with a fault trace mapped by Dooley (1973), Frizzell and Brown (1976), and Dames and Moore (1972) (figures 2, 3a).

MT. GEORGE QUADRANGLE

The Green Valley fault in the Mt. George quadrangle is a north to northwest trending right-lateral strike-slip fault (Wesson, et al, 1975). First mapped by Weaver (1949), the main trace of the Green Valley fault is generally located along ridge-top trenches within Pliocene Sonoma Volcanics. Subsequent maps by Sims, et al (1973) and Frizzell and Brown (1976) agree in general as to the main trace of the Green Valley fault, although differences in detail exist (figures 3b, 4). Brown (1970) differs as to the location of the main trace of the Green Valley fault, mapping a more arcuate northwest-trending fault through Lakes Frey and Madigan to the west of the ridge-top trenches (not plotted in this report). Sims, et al and Frizzell and Brown also map the west branch of the Green Valley fault, although differences in location and length of faulting occur (figures 3b, 4).

Geomorphic evidence of recent faulting is summarized on figures 3b and 4. Faulting is generally within Pliocene volcanic rocks along the main trace of the Green Valley fault and Holocene deposits are very sparse. Therefore, geomorphic evidence indicating Holocene fault activity must be relied upon. There are very few right-laterally deflected drainages along the main trace of the Green Valley fault, because the fault is located mainly along topographic highs and few drainages actually cross the fault.

Main traces of the Green Valley fault are moderately well-defined from the northern end of Green Valley north to the SW 1/4 of the NW 1/4 of section 14, T5N, R3W (figure 3b, 4). Evidence of recent faulting along two fault traces in section 23 includes sidehill benches, deflected drainages, scarps, linear trough (trench of Frizzell and Brown), possible beheaded drainages, closed depression, and tonal lineament in colluvium/alluvium (?) (figures 3b, 4). North of section 14 the Green Valley fault is concealed by massive landsliding (figures 3b, 4). Geomorphic evidence of recent faulting can be observed at locality 7, where right-laterally deflected drainages and a small linear ridge (shutter ridge of Frizzell and Brown) delineate the fault (figures 3b, 4).

Areas inspected for evidence of fault creep by this writer are shown on figure 4. No evidence was observed except at locality 8. Cracks oriented perpendicular to the trend of an asphalt road are crudely right stepping and are on trend with the mapped trace of the Green Valley fault. However, the road crosses a prominent west-facing scarp and the cracks are more likely caused by downslope movement than by fault creep.

Frizzell and Brown map a fault trace on the west side of the ridgetop trench in sections 3 and 34, based on a bench and a right-laterally deflected drainage (figure 3b). However, the bench is partly obscured by vegetation and is difficult to accurately map using air photo interpretation. A tonal lineament and bench were observed along the trend of Frizzell and Brown's west fault trace, based on air photo interpretation by this writer (locality 9, figures 3b, 4).

The Green Valley fault changes trend just north of locality 9 (figure 4). Frizzell and Brown map a single fault trace through the linear ridge-top trench (locality 10, figures 3b, 4), but two parallel faults were mapped by this writer, based on air photo interpretation (figure 4). Tonal lineaments in colluvial deposits of Sims and Frizzell (1976), a closed depression, and a well-defined scarp characterize the fault at this location.

Geomorphic evidence indicating Holocene fault activity such as deflected drainages, beheaded drainage, and a closed depression within a linear sidehill trough characterize the Green Valley fault in sections 28 and 21, T6N, R3W (figures 3b, 4). West of this location, a north -trending fault is delineated by a well-defined east-facing scarp and linear trough (locality 11, figures 3b, 4). Two possible branch faults near the border between sections 28 and 21 are characterized by linear troughs (figure 4).

Frizzell and Brown map a west branch of the Green Valley fault that passes under Lake Frey and east of Lake Madigan (figure 3b). Geomorphic evidence for the west branch Green Valley fault is summarized on figure 3b. Generally, no specific evidence of recently active faulting was observed along the west branch of the Green Valley fault, based on air photo interpretation by this writer (figure 3b).

The linear valley from Lake Frey southeast through sections 15, 22, and 23 is no doubt fault controlled (Sims, et al, 1973). However, specific geomorphic features permissive of Holocene-active faulting are either poorly-defined or were not observed by this writer, based on air photo interpretation.

Evidence of possible Holocene-active faulting was observed just north and east of Lake Frey where a west-facing scarp, tonal lineament in alluvial fan, and possible vertically offset drainages characterize a north-trending fault mapped by Frizzell and Brown (figure 3b). The sense of offset along this feature is vertical, east side up, rather than strike-slip. At locality 12, the scarp changes trend coincident with the change in trend of the drainage to the west (figure 3b). No geomorphic evidence of faulting was observed in the west-trending ridge just to the north of locality 12, based on air photo interpretation by this writer (figure 3b).

These geomorphic features may indicate recent faulting, but they could also be caused by stream erosion. A modified bench just east and above the west-facing scarp is bounded on the east by an additional west-facing scarp (locality 13, figure 3b). It is possible that these scarps were formed by downcutting of the drainage, isolating terraces above the river.

There is evidence that major drainage disruptions have occured in the Lake Frey-Lake Madigan area. The drainage course now occupied by Lake Madigan once drained to the west into Napa Valley, but was captured and now drains to the south into Lake Frey. The drainage from Lake Frey once flowed to the southeast through the fault controlled linear valley located diagonally across section 15. A large landslide (SW 1/4 section 10) blocked drainage to the southeast and eventually a lateral tributary at locality 14 (figure 4) captured the drainage. The saddle (or trough, figure 3b) southeast of locality 14 considered by Frizzell and Brown to be a recently-active fault feature may be the result of the impounded drainage cutting down through the landslide mass. Before the drainage was re-established, the lateral tributary succeeded in diverting drainage into Wild Horse Creek.

No geomorphic evidence of recent faulting was observed along the west branch fault of Frizzell and Brown from locality 12 north through section 33 (figure 3b). There is no systemmatic offset of drainages and Sims, et al do not map a fault along this location (figure 3b, 4). A "sag depression" mapped by Frizzell and Brown (locality 15, figures 3b, 4) is associated with a subtle, modified east-facing scarp and a vague tonal lineament. The north-trending fault at locality 11 near Jenkins Rock is on trend with the "sag depression" of Frizzell and Brown, although geomorphic evidence of recent faulting was not observed by this writer between the "sag depression" and the east-facing scarp and trough in the north-central part of section 28 (figures 3b, 4).

Geomorphic features suggesting Holocene strike-slip faulting were observed along a north-northwest trend at locality 16 (figure 4), based on air photo interpretation by this writer. A left-laterally deflected drainage associated with a sidehill bench and a beheaded drainage indicate Holocene activity. Frizzell and Brown do not map these features. Sims, et al map serpentine within massive landslide deposits roughly on trend with a fault in Cretaceous sedimentary rocks near locality 16, but they do not map the fault in the overlying Sonoma Volcanics. The scarp of a large landslide mapped by Sims and Frizzell (1976) coincides with the location of these geomorphic features, strongly suggesting that the Holocene-active features are due to landsliding rather than faulting.

A continuation of the north-northwest trending features to the southeast was not observed by this writer, but massive landslides occur for about 4 1/2 miles to the southeast (figure 4). There is a vague suggestion of right-laterally deflected drainages northwest into Wooden Valley, but the offset is not systematic. Tonal lineaments in alluvium observed in Wooden Valley are generally abandoned stream channels, although there is a preferred northwest-southeast orientation along the general trend of the features near locality 16 (figure 4).

The Green Valley fault is defined by a zone of seismicity in the FER study area (figure 5). Epicenters occur in greater numbers north of the study area, indicating that the Green Valley fault zone continues to the north beyond Wooden Valley. The Green Valley fault is probably located along the west side of Wooden Valley, but geomorphic evidence of recent faulting is obliterated by massive landslides. Frizzell and Brown do not map the Green Valley fault north of locality 17 (figure 3b).

Herd (p.c., August 1981) has mapped the northern extension of the Green Valley fault zone for at least 40 km north of the FER study area. A zone of seismicity coincides with the location and trend of recently-active faults mapped by Herd (USGS, 1980). The northern extension of the Green Valley fault zone will be evaluated as time and priorities permit.

6. Conclusions

CORDELIA QUADRANGLE

The Green Valley fault is generally well-defined in most of the Cordelia quadrangle and is associated with geomorphic features mandatory of Holocene-active faulting such as closed depressions, tonal lineaments and scarps in alluvium, and evidence indicating right-lateral strike-slip fault creep (figures 2, 3a). A right-laterally offset stone fence and power transmission tower alignment suggest a 3mm/yr fault creep rate. There is good agreement in general as to the location of traces of the Green Valley fault mapped by Dames and Moore (1972), Sims et al (1973), Dooley (1973), and Frizzell and Brown (1976) (figure 2, 3a).

The fault trace mapped by Dooley at locality 1 is located in massive landslide debris and is not a well-defined feature. Air photo lineaments mapped by Dooley east of the main traces of the Green Valley fault are based on linear or right-laterally deflected drainages that have no geomorphic evidence of structural continuity. Burkland and Associates (1976) and Leighton and Associates (1977; cited in Western Geological Consultants, 1979) excavated trenches across three air photo lineaments mapped by Dooley. No evidence of faulting was observed in the excavations.

The main trace of the Green Valley fault mapped by Frizzell and Brown (1976) is well-defined in sections 11 and 2, T4N, R3W and is characterized by geomorphic features indicating Holocene-active faulting such as closed depressions, tonal lineaments in alluvium and across an alluvial fan, and deflected drainages (figure 3a). A similar fault is mapped by Sims, et al (1973), but their fault trace is located from 150 to 300 feet east of the fault trace mapped by Frizzell and Brown (figures 2, 3b).

Main traces of the Green Valley fault are locally well-defined from Interstate 80 south-southeast to the quadrangle border, although some segments of the fault zone are subtle (figure 3a). Fault exposures in trenches excavated by Dames and Moore (1972), Burkland and Associates (1973), and Geomechanics (1978) generally have coincided with geomorphic features observed by Frizzell and Brown (1976) and Bryant (this report) (figures 2, 3a), locally providing good control for the location and recency of faulting. Faulted adobe soil exposed in a trench excavation by Dames and Moore (1972) is considered to be Holocene in age (U.S.G.S., 1973).

The branch fault at locality 3 (figure 2, 3a) mapped by Sims, et al (1973) and Frizzell and Brown (1976) is not a well-defined feature and Dooley (1973) indicates that west-trending faults offset this northwest-trending fault. Faulting is generally confined to the Sonoma Volcanics and the only evidence suggesting Holocene activity (a modified closed depression) is not clearly related to faulting (figure 3a).

Faults mapped by Frizzell and Brown (1976), Dames and Moore (1972), and selected short segments mapped by Bryant (figure 3a, this report) adequately delineate the principal active branches of the Green Valley fault in the Cordelia quadrangle.

MT. GEORGE QUADRANGLE

The Green Valley fault zone is locally well-defined in the Mt. George quadrangle, although there are stretches along the fault zone that are poorly defined or concealed by massive landslides (figures 3b, 4). Evidence of Holocene offset is based largely on geomorphic features because the main traces of the fault zone are located within bedrock (Sonoma Volcanics) and very few Holocene deposits are located across the fault. The occurrence of offset drainages is rare along the main trace of the Green Valley fault due to the ridge-top trench location of the fault; drainages flow away from the fault zone rather than across it.

It is probable that some of the geomorphic features along the trend of the Green Valley fault zone are due at least partly to lateral spreading in addition to active faulting. An extremely large landslide complex just to the east of the main trace of the Green Valley fault probably contributes to any instability along the ridge area where the fault is located (figure 3b, 4). If lateral spreading is the principal cause of the ridge-top trenches considered to define the Green Valley fault, then one would expect a certain amount of dip-slip displacement across the trench. However, elevations on the east and west sides of the ridge-top trenches are remarkably similar in sections 28, 27, 34, T6N, R3W, and sections 3, 10, 11, T5N, R3W, suggesting that vertical offset due to gravitational forces has not been the major factor in the formation of the ridge-top trenches (figure 4).

Three fault strands mapped by this writer in sections 23 and 14, T5N, R3W, just north of Green Valley, are similar to faults mapped by Frizzell and Brown (1976), although differences in detail exist (figures 3b, 4). Geomorphic evidence permissive of Holocene-activity along these faults includes sidehill benches, deflected drainages, scarps, linear trough, possible beheaded drainages, closed depression, and a tonal lineament in colluvium/alluvium (?) (figure 4).

The main trace of the Green Valley fault is obscured by massive landslides, or is poorly defined, from the NW 1/4 of section 14 north to about the center of section 3 (figures 3b, 4). Right-laterally deflected and linear drainages within a ridge-top trench are permissive of Holocene-active faulting in section 3, T5N, R3W.

The Green Valley fault is well-defined in sections 28, and 21, T6N, R3W. Geomorphic evidence of Holocene-active faulting along this segment of the fault includes deflected drainages, beheaded drainages, and closed depression within a linear sidehill trough (figure 4). Well-defined faults south of Jenkins Rock in section 21, characterized by east-facing scarps and linear troughs, delineate the northernmost limit of well-defined recent faulting in the Mt. George quadrangle. Geomorphic evidence of faulting is obscured by massive landsliding north of section 21 (Frizzell and Brown, 1976) (figure 3b).

The west branch of the Green Valley fault mapped by Frizzell and Brown (1976) is not well-defined and geomorphic evidence of Holocene faulting was not observed along most of the fault trend (figure 3b). North-trending features just east and north of Lake Frey are suggestive of Holocene activity, but there is some uncertainty as to the cause of the Holocene features. The parallel trend of the features with the drainage, especially where the west facing scarp changes trend coincident with the change in trend of the drainage (locality 12, figure 3b), and the geomorphic evidence indicating significant stream piracy suggest that the west-facing scarps and recently incised tributary drainages may be the result of erosion rather than recent faulting.

Geomorphic features indicating Holocene-active offset east of the main trace of the Green Valley fault (locality 16, figure 4) generally are coincident with a landslide scarp mapped by Sims and Frizzell (1976).

Geomorphic features north into Wooden Valley are not well-defined. Thus it is probable that the geomorphic features at locality 16 were formed by landsliding rather than faulting.

Selected faults mapped by Frizzell and Brown (1976), supplemented with selected fault segments mapped by Bryant (figure 4, this report) adequately delineate sufficiently active and well-defined faults of the Green Valley fault zone.

7. RECOMMENDATIONS

Recommendations for zoning faults for special studies are based on the criteria of sufficiently active and well-defined (Hart, 1980).

CORDELIA QUADRANGLE

Zone for special studies well-defined traces of the Green Valley mapped by Frizzell and Brown (1976), Dames and Moore (1972), and Bryant (this report, figure 3a) as shown on figure 6a. Delete the east branch fault of Sims, et al (1973) at locality 3 (figure 2), and the west branch fault (locality 1, figure 2) and air photo lineaments mapped by Dooley (figure 2). These faults are not sufficiently active or well-defined.

MT. GEORGE QUADRANGLE

Zone for special studies well-defined traces of the Green Valley fault mapped by Frizzell and Brown (1976) and selected fault traces mapped by Bryant (figure 4, this report) as shown on figure 6b. Do not zone the west branch of the Green Valley fault mapped by Frizzell and Brown (1976). This fault is not sufficiently active or well-defined.

8. REPORT PREPARED BY WILLIAM A. BRYANT, April 29, 1982.

William A. Bryant

Report reviewed and recommendations seem quite reasonable.
EWH
7/2/82

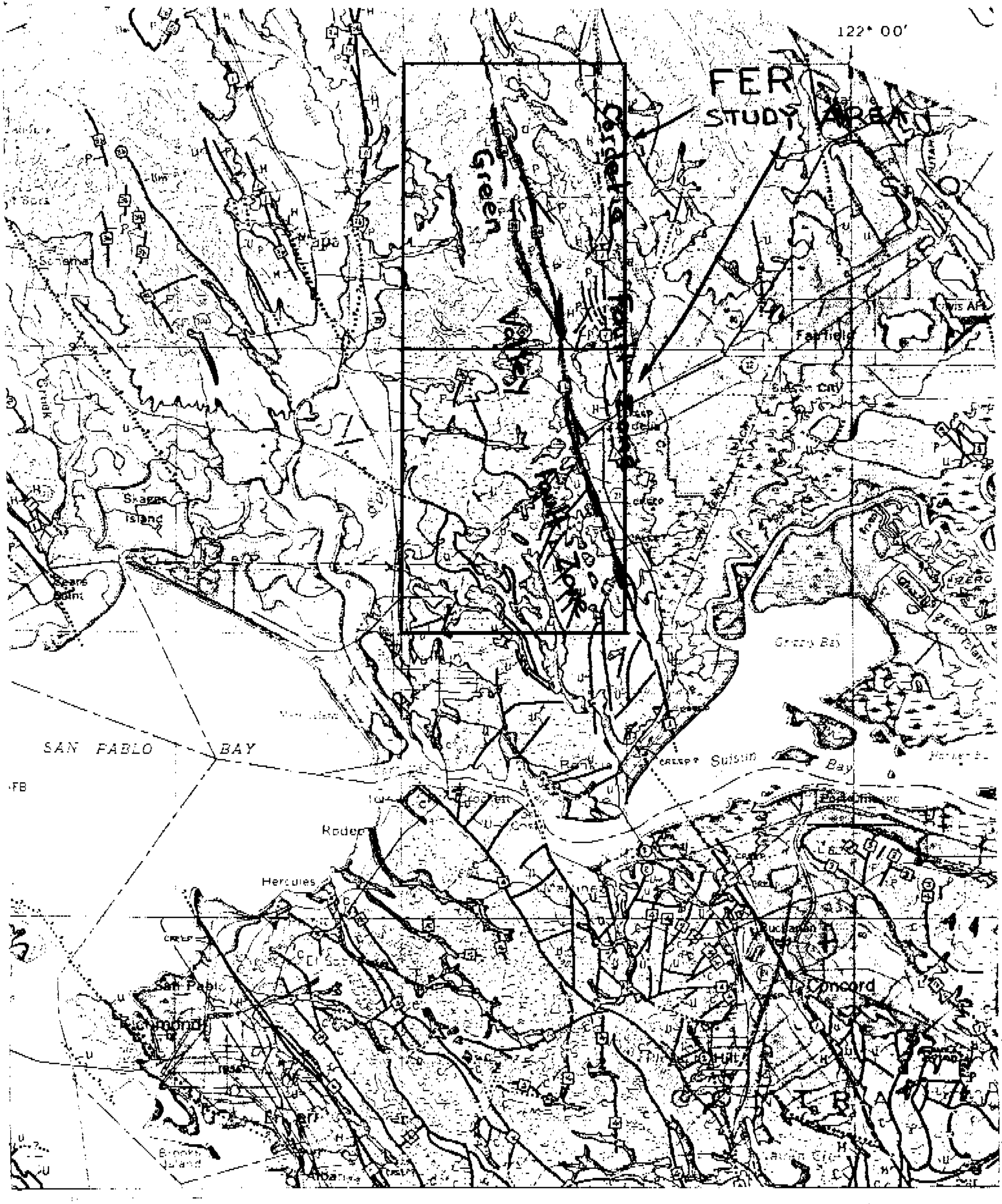

Figure 1 (to FER-126). Location of Green Valley fault zone evaluated in FER-126. From Pampayen, 1979.

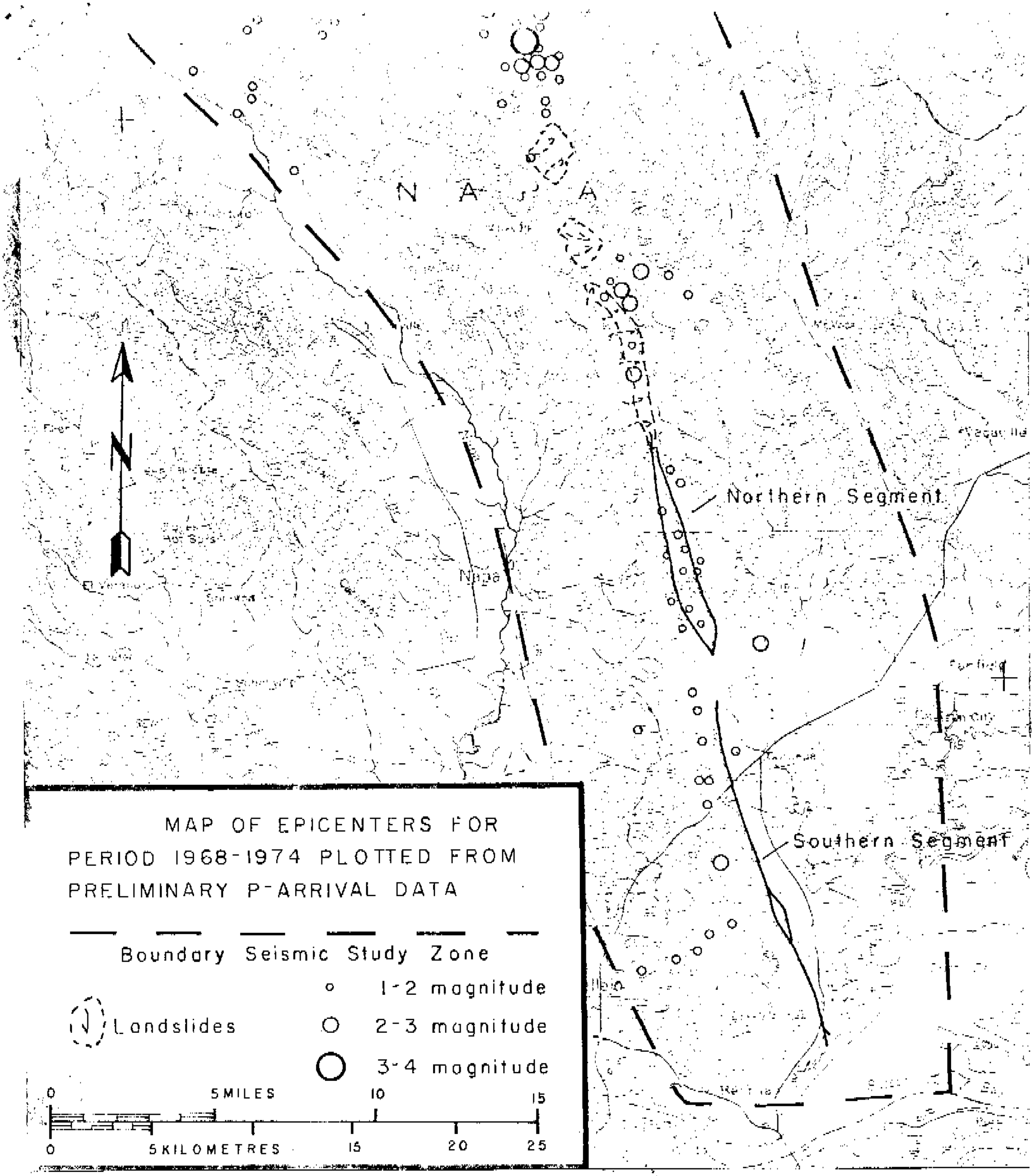

Figure 5 (to FER-126). Seismicity along the Green Valley fault zone (from Frizzell and Brown, 1976).